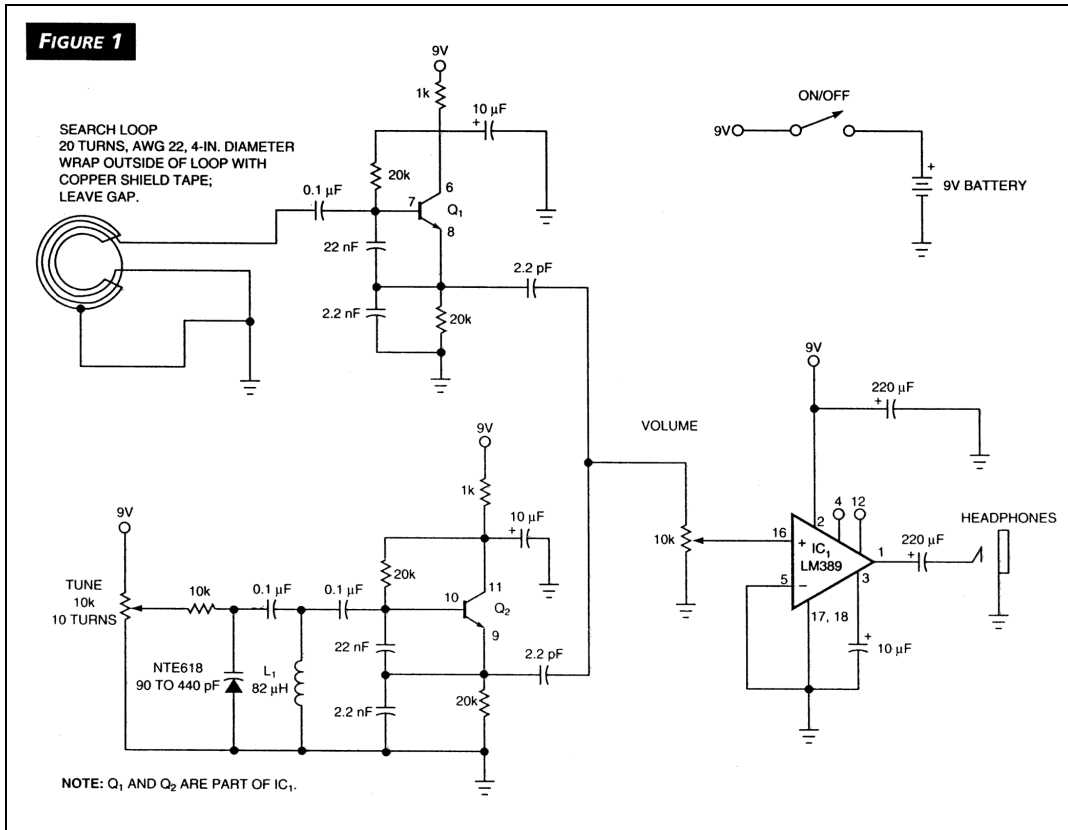


Metal detector uses single IC

RACHEL AND STEVE HAGEMAN, HEWLETT-PACKARD, SANTA ROSA, CA

The original application of the circuit in Figure 1 was to locate coins, but it applies wherever you need to locate metal objects. The circuit uses a beat-frequency technique: Whenever a metal object comes close to the search coil, the metal causes the coil's inductance to decrease. Though the inductance change is small in itself (a coin, for example, causes a small frequency shift), beating the frequency against that of another fixed oscillator at almost the same frequency produces a noticeable audio-frequency shift.



Beating two frequencies together produces an audible shift in tone when the search coil in this simple metal detector comes near a metal object.

The inductance of the search loop and the input capacitance (series combination of the three input capacitors, or approximately 2nF) of the Q1 oscillator determine the frequency of the search oscillator. In this design, the frequency is approximately 370kHz. For years, this frequency has prevailed in metal detectors, because it yields the lowest sensitivity to ground conditions, such as moisture and density.

You can change the inductance of the search coil by modifying its turns count or diameter. The loop has Faraday shielding to reduce capacitive-coupling effects. You can fabricate a simple Faraday shield by using adhesive copper tape of the sort used in EMI shielding. Simply wrap the completed loop with the foil tape. Make sure the tape has a gap at one point around the loop, or a shorted-turn transformer results. You should mechanically secure the loop to a nonmetallic form to prevent microphonics.

With the prescribed 4-in. diameter, the search coil in this design lets you detect a penny buried approximately 2 in. in the ground. If you wish to detect larger objects at greater depths, you can build a larger search coil. To keep the oscillator frequency roughly the same, you should halve the number of turns for every doubling of the coil's

diameter. The Q2 beat oscillator uses a similar Colpitts design. However, instead of using inductance changes for tuning, the beat oscillator uses a varactor diode. Depending on your exact search-coil inductance (hence, oscillation frequency), you may need to adjust L1 to obtain adequate tuning range in the beat oscillator.

Both oscillators have light coupling to the remaining audio section of the LM389. The amplifier, whose gain is approximately 26dB, easily drives a set of 8 ohm headphones. If you need more gain, you can add a 10uF capacitor between pins 4 and 12 of the LM389. The prototype detector uses some polyvinyl-chloride sprinkler pipes and fittings to provide a convenient handle and chassis for the electronics. Operating the metal detector is simple. Place the search coil on the ground, and adjust the tune potentiometer for a tone of approximately 100Hz. Then, taking care to keep the search coil at a fixed distance from the ground, slowly sweep the coil over the area of interest.

Metal objects cause a change in the audible tone. The relative amount of tone shift indicates the object's size and depth. The greater the tone shift, the bigger or closer the object is. You should avoid "zero beating" the two oscillators, because they will lock with each other, thereby reducing the search oscillator's sensitivity. You can add a meter output for visual or automatic control by adding a highpass filter to the LM389's output. This highpass output, operated below the corner frequency, changes in amplitude as the frequency increases. Rectifying the output yields a positive indication of the metal object's proximity to the search coil. By digitizing the meter output and using a single-chip uP with a DAC to control the beat oscillator, you can make a complete closed-loop control system for industrial applications.

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